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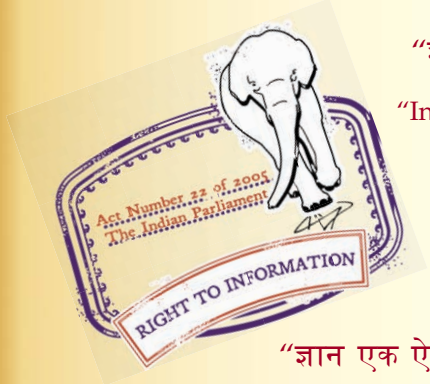
IS 10579 (1983): Polyethylene (PE) insulation and sheath of telecommunication cables [LITD 6: Wires, Cables, Waveguides and Accessories]



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Bhartṛhari—Nītiśatakam
"Knowledge is such a treasure which cannot be stolen"

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IS : 10579 - 1983

Indian Standard

SPECIFICATION FOR POLYETHYLENE (PE) INSULATION AND SHEATH OF TELECOMMUNICATION CABLES

UDC 621·315·221·8 : 621·315 616·96 : 678·742·2 : 621·39

INDIAN STANDARDS INSTITUTION
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

Gr 4 *September* 1983

Indian Standard

SPECIFICATION FOR POLYETHYLENE (PE) INSULATION AND SHEATH OF TELECOMMUNICATION CABLES

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LTDC 18

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AMENDMENT NO. 1 JULY 1984

TO

IS : 10579-1983 SPECIFICATION FOR POLYETHYLENE (PE) INSULATION AND SHEATH OF TELECOMMUNICATION CABLES

Alteration

(Page 5, *clause 3.6.1₁ heading)* - Substitute *'Recommended Colours'* for *'Standard Colours'.*

(LTDC 18)

Reprography Unit, ISI, New Delhi, India

Indian Standard

SPECIFICATION FOR POLYETHYLENE (PE) INSULATION AND SHEATH OF TELECOMMUNICATION CABLES

0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 20 May 1983, after the draft finalized by the Wires and Cables for Electronic Equipment Sectional Committee had been approved by the Electronics and Telecommunication Division Council.

0.2 With a view to covering in a single standard the requirements and test methods for polyethylene (PE) insulation and sheath of telecommunication cables, this standard has been prepared. This standard is complementary to the relevant telecommunication cable specifications.

0.3 This standard applies to polyethylene (PE) insulation and sheath of telecommunication cables. The requirements for polyethylene (PE) insulation and sheath for power cables are covered in IS : 6474-1971*.

0.4 The Committee responsible for the preparation of this standard has taken cognizance of the desirability of including a test for brittleness temperature, which, however, is not included in this standard due to lack of testing facilities. The test may be done, if agreed to between the manufacturer and the purchaser.

0.5 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test, shall be rounded off in accordance with IS : 2-1960†. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

1. SCOPE

1.1 This standard specifies physical and electrical requirements and test methods for various types of polyethylene (PE) insulation and sheath

*Specification for polyethylene insulation and sheath of electric cables.
†Rules for rounding off numerical values (*revised*).

of telecommunication cables taken, where possible, from the cables after manufacture.

NOTE 1 — The types of PE compounds recognised for the purpose all contain antioxidants.

NOTE 2 — PE co-polymers have not yet been included in this standard. It is intended to include them when sufficient data is available.

NOTE 3 — Unless otherwise specified in the relevant cable specifications, sheath compounds shall also contain carbon black of suitable type uniformly dispersed throughout the material.

1.2 This standard does not deal with cross-linked or cellular materials and materials for special applications, for example, coaxial cables for submarine, CATV, RF or other applications.

2. TERMINOLOGY

2.0 For the purpose of this standard, the definitions given in IS : 1885-(Part XXXII)-1971* and IS : 2530-1963† shall apply.

3. REQUIREMENTS

3.1 Density Range — Three types of PE extrusion materials are identified by density as follows:

Type	*Density Range, g/cm³*	
Low density PE (LDPE)	$\leqslant 0{\cdot}925$	23°C
Medium density PE (MDPE)	$> 0{\cdot}925 \leqslant 0{\cdot}940$	
High density PE (HDPE)	$> 0{\cdot}940$	

NOTE 1 — These densities refer to unfilled resins as determined by the method specified in Appendix A for compounds containing carbon black; a correction factor of + 0·0l g/cm³ may be used. In case of doubt, the correction formulae given in A-2.5.1 may be used.

NOTE 2 — For insulation of jelly filled cables, use of MDPE or HDPE materials is recommended.

3.1.1 The method for determination of density is described in Appendix A.

***Electrotechnical vocabulary: Part XXXII Cables, conductors and accessories for electricity supply.**

†Methods of test for polyethylene moulding materials and polyethylene compounds.

3.2 Melt Flow Index (MFI) — The material shall be classified by melt flow index and nominal carbon black content in the following categories:

Classification	*Nominal MFI*	*MFI Range*	*Nominal Carbon Black Content*
03	0·3	0·1 to 0·6	Nil
03C	0·3	0·1 to 0·6	2·5 percent
2	2	1·5 to 3	Nil
2C	2	1·5 to 3	2·5 percent

NOTE 1 — In the classification, 'C' indicates presence of carbon black. These are used for sheathing material.

NOTE 2 — Material with other MFI may be used for special applications subject to agreement between the manufacturer and the user.

3.2.1 The melc flow index (MFI) of a sample of insulation or sheath taken from the cable shall be determined by the method described in **7** (Method A) of IS : 2530-1963*.

3.3 Tensile Stress At Yield and Elongation at Break — The tensile stress at yield and elongation at break shall be determined on specimens of insulation and sheath removed from the cable according to the method described in Appendix B. The requirements are given in Table 1.

3.4 Carbon Black

3.4.1 *Carbon Black Content* — For those materials with carbon black content specified (*see* **3.2**), it shall be between 2 and 3 percent, when determined as prescribed in **10** of IS : 2530-1963*.

TABLE 1 TEST REQUIREMENTS

(Clauses **3.3** *and* **3.8.2)**

CHARACTERISTIC	REQUIREMENT		
	LDPE	MDPE	HDPE
Tensile stress at yield MN/m^2, *Min*	7	10	12
Elogation at break, percent, *Min*	300	300	300
Power factor, unpigmented, *Max*	0·000 3	0·000 3	0·000 3
Power factor, pigmented, *Max*	0·000 9	0·000 9	0·000 9
Permittivity, *Max*	2·3	2·32	2·35

NOTE — The requirements of power factor and permittivity are generally significant only for compounds classified as not containing carbon black (*see* 3.2).

*Methods of tests for polyethylene moulding materials and polyethylene compounds.

3.4.2 *Carbon Black Dispersion* — The dispersion of carbon black in the material shall be satisfactory, when tested as prescribed in Appendix C.

3.5 Antioxidant — All PE compounds shall have been processed with an antioxidant. A copper deactivator or inhibitor may be added, if required.

The amount of residual antioxidant/inhibitor in the compound removed from the cable shall be such as to meet the requirements of Appendix D. For this test, sheets of thickness 1·3 ± O·l mm shall be prepared as in **3.8.1.1,**

3.6 Colours — Pigmented compounds shall be such that the additional requirements listed below are met.

3.6.1 *Standard Colours* — The colour of the pigmented compound shall be as specified in IS : 9938-1981*.

3.6.2 *Colour Fastness to Daylight* — A sample of core or sheath shall be tested as prescribed for PVG in IS : 5831-1970† and the colour fastness to daylight exposure shall be rated at not less than 4.

3.6.3 *Colour Fastness to Water* — Whes a piece, about 100 mm long, of insulation or sheath is cut into small pieces and immersed for 48 hours in about 10 times its own volume of distilled water maintained at 70 ± 1°C, and the water examined at the end of this period, the water shall be free from any trace of colour.

3.6.4 *Bleeding and Blooming* — A sample of core or sheath shall be tested as prescribed for PVG in IS : 5831-1970†, except that a sheet or tape of unpigmented PE without antioxidant shall be used instead of the transparent PVC indicator. The melt flow of the PE indicator shall be not greater than 3. There shall be no appreciable staining of the indicator tape or of the filter paper.

3.7 Environmental Stress Cracking — Sheaths removed from cables shall withstand the test described in Appendix B of IS : 6474-1971‡ with no failures using Igepal solution of 10 percent strength.

3.8 Power Factor and Permittivity

3.8.1 Where required, a suitable quantity of insulation or sheath, belt or filler shall be taken from the finished cable and moulded into a sheet of uniform thickness to provide a test specimen. The method of moulding the sheet shall be as follows.

*Recommended colours for PVC insulation for LF wires and cables.
†Specification for PVC insulation and sheath of electric cables.
‡Specification for polyethylene insulation and sheath of electric cables.

3.8.1.1 A sufficient quantity of PE compound is taken from the cable and moulded into sheets suitable for the preparation of test specimens. The sheets are prepared by moulding, at a temperature of at least 160°C, with a suitable mould in a hydraulic press to give a thickness as follows:

Test	*Thickness of Sheet*
Power factor and permittivity	0·5 to 2·5 mm
Residual antioxidant	1·3 mm, approx

3.8.1.2 The plates are brought together gradually as PE melts and full pressure is applied after 5 to 6 minutes heating. The moulding is kept under pressure at moulding temperature for about 3 minutes, the heat is then turned off and cooling water turned on. Pressure is released when the plates are cool enough to handle and the sheet is then removed from the mould.

3.8.2 The power factor and permittivity of specimen shall be measured at a frequency of 1 to 20 MHz in accordance with IS : 4486-1967* or by any other method which can be shown to give the same results. The power factor and permittivity shall not exceed the appropriate values given in Table 1. The test shall be conducted within 24 hours of preparation of the *test sheet.*

APPENDIX A

(Clauses 3.1.1 *and* B-4.1)

METHOD FOR DETERMINING DENSITY OF PE

A-l. SUSPENSION METHOD

A-l.l Testing Equipment — The test equipment consists of:

a) ethanol (ethyl alcohol) for analysis or any other suitable liquid for densities equal or below 1 g/cm^3,
b) zinc chloride solution for densities greater than 1 g/cm^3,
c) distilled water,
d) mixing cylinder,
e) thermostat,
f) hydrometer calibrated at 23°G, and
g) thermometer with 0·1°C divisions.

*Recommended methods for the determination of the permittivity and dielectric dissipation factor of electrical insulating materials at power, audio and radio frequencies including metre wavelengths.

A-1.2 Test Procedure

A-l.2.1 From the insulation or the sheath to be tested, a sample is taken perpendicularly to the conductor axis and is cut into small pieces of 1 to 2 mm edge length. The density is determined by putting the sample in suspension in a liquid which does not react with the material to be tested. The following liquids are suitable:

a) A solution of ethanol in water for a density expected to be lower than 1 g/cm^3, and

b) A solution of zinc chloride in water for a density of 1 g/cm^3 and higher.

A-l.2.2 Three pieces of the sample are placed into the liquid at a temperature of 23 ± 0·1°C, avoiding any formation of air bubbles. Distilled water is added to the liquid until the pieces are freely suspended within the liquid in the mixing cylinder. The liquid solution shall be homogeneous and maintained at the indicated temperature. The density of the liquid solution is determined by means of a hydrometer and indicated to three decimal places. The determined density being the same as that of the samples under test.

A-2. PYCNOMETER METHOD (REFERENCE METHOD)

A-2.1 Apparatus — The apparatus for this method consists of:

a) a balance with a precision of 0·1 mg,

b) a pan straddle or other stationary support,

c) a pycnometer of 50 ml capacity, and

d) a liquid bath provided with a thermostatic control.

A-2.2 Sampling — The specimen should be taken from bare insulation or sheath. The mass of the specimen should be not less than 1 g and not greater than 5 g. The specimen should be made by cutting the sample of insulation or sheath into a number of small pieces; small tubes of insulation or sheath should be cut longitudinally into two or more parts to prevent the enclosure of air bubbles.

A-2.3 Conditioning — The specimen should be at an ambient temperature of 23 ± 3°C.

A-2.4 Test Procedure — Weigh the pycnometer empty and dry, then weigh a suitable quantity of the specimen in the pycnometer. Cover the test specimen with immersion liquid (ethanol 96 percent) and remove all air from the specimen, for example, by applying a vacuum to the pycnometer standing in a desiccator. Break the vacuum (if applied) and fill the pycnometer with the immersion liquid. Bring it to

a temperature of 23 ± 0·5°C in the bath, and then complete filling exactly to the limits of the capacity of the pycnometer. Wipe dry and weigh the pycnometer with its contents. Empty and fill with the immersion liquid, remove the air and determine the weight of the contents and pycnometer at 23 ± 0·5°C.

A-2.5 Calculation — Calculate the density of the PE insulation and sheath from the following relation:

$$\text{Density at 23°C} = \frac{m \times \rho_L}{m_1 - m_2}$$

where

m = mass of specimen, in g;

m_1 = mass of liquid required to fill the pycnometer, in *g;*

m_2 = mass of liquid required to fill the pycnometer, when containing the specimen, in g; and

ρ_L = density of immersion liquid at 23°G (ethanol 96 percent 23°G = 0-798 8 g/cm^3).

A-2.5.1 For compounds containing carbon black the correction is made, before rounding off, by the following formula:

$$\rho = \rho_c - 0{\cdot}004\,5 \times c_B$$

where

ρ = density of PE (corrected value),

ρ_c = density of PE compound (measured value), and

c_B = numerical value of percentage of carbon black content of the material (determined according to **3.4.1,** if necessary).

APPENDIX B

(Clauses **3.3** *and* **E-2.1** **)**

TENSILE STRESS AT YIELD AND ELONGATION AT BREAK

B-l. GENERAL

B-l.l These tests shall determine the tensile strength, if required by the relevant cable specification, and elongation at break of insulation material (excluding semiconducting layers) and sheathing material

taken from pieces of cable as received (that is, without any ageing treatment).

NOTE — For the insulation of telecommunication cables, the measurement of the tensile strength is not recommended.

B-2. SAMPLING

B-2.1 The sampling shall be specified in the relevant cable specification.

B-3. PREPARATION OF TEST PIECES

B-3.1 Test pieces may be of two types: tubular and dumb-bell. The dumb-bell shall be used whenever possible. The tubular test piece cannot be used when there is a semiconductor layer bonded on the inner surface of the insulating wall.

B-3.2 Tabular Test Pieces — This-type shall be used only when the core is of such a small size that it is not possible to prepare a dumb-bell piece. This is *the* usual case with insulations.

A tube not less than 100 mm long is obtained by removal of all outer coverings and the conductor, care being taken not to damage the insulation/sheath.

If withdrawal of the conductor is difficult, it should be stretched by any suitable means.

A length of 20 mm is marked by two parallel lines, centrally on each piece, immediately before the tensile test. The specimen shall be under no tension at the time of marking.

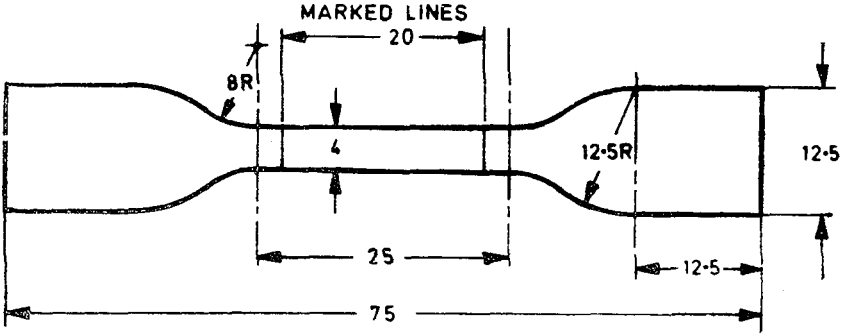
B-3.3 Dumb-bell Test Pieces — The insulation sheath shall be cut open in the direction of the axis and the conductors shall be removed.

The insulation/sheath shall be cut, care being taken to avoid undue heating. After cutting, two parallel surfaces shall be obtained; the thickness of the pieces shall be not less than 0·8 mm and not more than 2·0 mm.

After this preparation, one dumb-bell according to Fig. 1 shall be punched or, if possible, two dumb-bells shall be punched side by side.

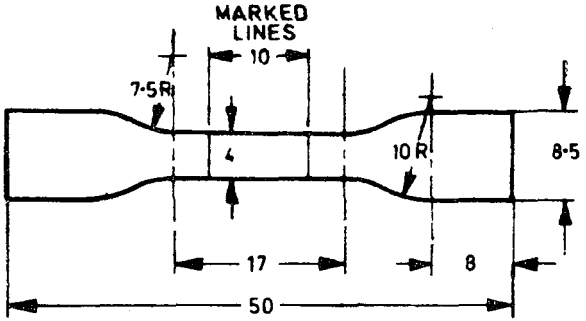
When the diameter of the core/sheath is too small, one dumb-bell test piece according to Fig. 2. shall be punched.

Immediately before the tensile test, a length of 20 mm is marked by two lines centrally on each dumb-bell·



All dimensions in millimetres.

FIG. 1 DUMB-BELL TEST PIECE



All dimensions in millimetres.

FIG. 2 SMALL DUMB-BELL TEST PIECE

B-4. DETERMINATION OF CROSS-SECTIONAL AREA OF INSULATION

B-4.1 Cross-Sectional Area of the Tubular Test Piece — The cross-sectional area ***A,*** in square millimetres, of each test piece shall be determined from the density, the mass and the length, according to the following formula:

$$A = \frac{100\ m}{\rho \times l}$$

where

m = mass of the piece of specimen in g to three decimal places;

I = length in mm to one decimal place; and

p = density obtained from an additional sample of the same specimen, in g/cm^3, to three decimal places.

The density shall be determined by a generally accepted standard method, but the pycnometer method shall be considered as the reference method (*see* **3.1.1** and Appendix A). The density shall be measured on material before ageing.

B-4.2 Cross-Sectional Area of the Dumb-bell Test Piece — The cross-sectional area of each of the dumb-bell test pieces shall be calculated from the width and the smallest thickness of three measurements of the middle portion of the piece (between the marker lines).

In case of doubt, not only the thickness but also the width is measured at three points between the marker lines, and the width is measured on both surfaces of the test piece, taking the mean of the two values for the calculation of the cross-section.

The smallest of the three cross-sections so found is taken as relevant for the calculation of the tensile strength.

A measuring microscope allowing a reading of 0·0ll mm shall be used for measurement of thickness/width.

B-5. CONDITIONING OF TEST PIECES

B-5.1 All test pieces shall be kept for at least 3 hours before the tensile test at a temperature of 23 ± 5°C.

B-6. TEST PROCEDURE

B-6.1 Test Temperature — The tests shall be carried out at ambient temperature. Each test shall be completed within 5 minutes after removal of the test piece from the conditioning chamber. In case of doubt, the test shall be repeated at 23 ± 3°G.

B-6.2 Distance Between The Grips and Rate of Separation — The grips of the tensile machine may be either of a self-tightening type or of a non-self-tightening type for both dumb-bell and tubular test pieces.

B-6.2.1 The total length between the grips shall be about:

a) 34 mm in the case of small dumb-bells according to Fig. 2;

b) 50 mm in the case of dumb-bells according to Fig. 1;

c) 50 mm in the case of tubes, if tested with self-tightening grips; and

d) 85 mm in the case of tubes, if tested with non-self-tightening grips.

B-6.2.2 The rate of separation shall be:

a) 250 ± 50 mm/min for PE of a density $\leqslant$ 0·925 g/cm^3, and

b) 25 ± 5 mm/min for PE of a density > 0·925 g/cm^3.

NOTE — For routine tests, medium or high density PE may be treated as low-density PE. In case of failure, however, the test shall be repeated at the lower speed to check conformity.

B-6.3 Measurements — The tensile strength and the elongation at break shall be determined simultaneously on the same specimen.

The elongation shall be determined by measuring the distance between the two marker lines at the moment of rupture.

Unsatisfactory results due to damage in the grips shall be ignored; in such a case, at least four valid results are required in order to calculate the tensile strength and the elongation at break, otherwise the test shall be repeated.

B-7. EXPRESSION OF RESULTS

B-7.1 All breaking loads including breaking loads of samples after ageing (*see* Appendix E), if specified, shall be referred to the cross-sectional area of the conditioned test piece for calculation of tensile strength. The median of the values of tensile strength shall be recorded as the tensile strength, likewise for the elongation at break.

APPENDIX C

(Clause 3.4.2)

TEST FOR CARBON BLACK DISPERSION AT 200 X IN PE

C-l. INTRODUCTION

C-l.l This test is for determining whether carbon black in PE compounds, extrusions or moulded articles, is satisfactorily dispersed. For PE compounds all specimens of the material are squeezed into a thin layer between microscope slides at a temperature high enough to melt the material. The appearance by transmitted light is then compared at a magnification of 200 with that of a standard photomicrograph. The same procedure may be applied to extruded or moulded articles but alternatively a thin section may be cut with microtome from the article and examined in the microscope.

C-2. PROCEDURE

C-2.1 The clean microscope slides shall be placed on a hotplate-maintained at 170 to 210°G. Three specimens of pin-head size (of mass approximately 5 mg), each cut from a separate granule or from a separate part of a moulded or extruded article, shall be placed approximately 19 mm apart on one of the hot microscope slides.

C-2.2 A piece of metal shim 38 mm long, 19 mm wide and 0·03 mm thick shall be placed at each end and the whole covered with the other hot microscope slide. Specimens shall be pressed cut by applying even pressure for 1 to 2 minutes to the whole area of the face of the upper slide. After the specimens have been placed on the slides, these shall not remain on the hotplate for more than 3 minutes.

C-2.3 When the slides are cool enough to be handled, the three specimens shall be examined through a microscope at a magnification of 200 ± 10 with a field of view of 1 ± 0·l mm diameter.

C-2.4 Alternatively, for PE in the form of extrusions or moulded articles, a microtome section about 0·03 mm thick shall be examined at a magnification of 2.00 as for compounds; the process of pressing the material between hot microscope slides being omitted.

C-2.5 The whole of each specimen shall be compared with the photomicrograph (Fig. 3 to 14) for the material in respect of number and size of agglomerates. Note shall also be made of any lack of uniformity of the background.

Fig, 3 to 8 illustrate satisfactory dispersion and Fig. 9 to 14 unsatisfactory dispersion.

C-2.6 The carbon black dispersion in the material under test shall be considered to be satisfactory if the specimens show a uniform background free from white streaks and if the number and size of agglomerates in the specimens are not greater than those shown in Fig. 3 to 8.

C-3. REPORT

C-3.1 The report shall state whether the carbon black dispersion is satisfactory or unsatisfactory.

APPENDIX D

(Clause 3.5)

TEST FOR RESIDUAL LEVEL OF ANTIOXIDANT

D-l. UNKNOWN ANTIOXIDANT

D-l.l Where the antioxidant is unknown, and subject to agreement between the manufacturer and user, PE aged in accordance with **D-2** shall not show an increase in the power factor of more than 0·000 3 above that determined prior to ageing. The power factor shall be measured on instrumentation capable of an accuracy of ± 0·000 05. For sheathing grades, this test shall be carried out on material supplied without the inclusion of carbon black. Tests on insulant grades shall be carried out on the pigmented material.

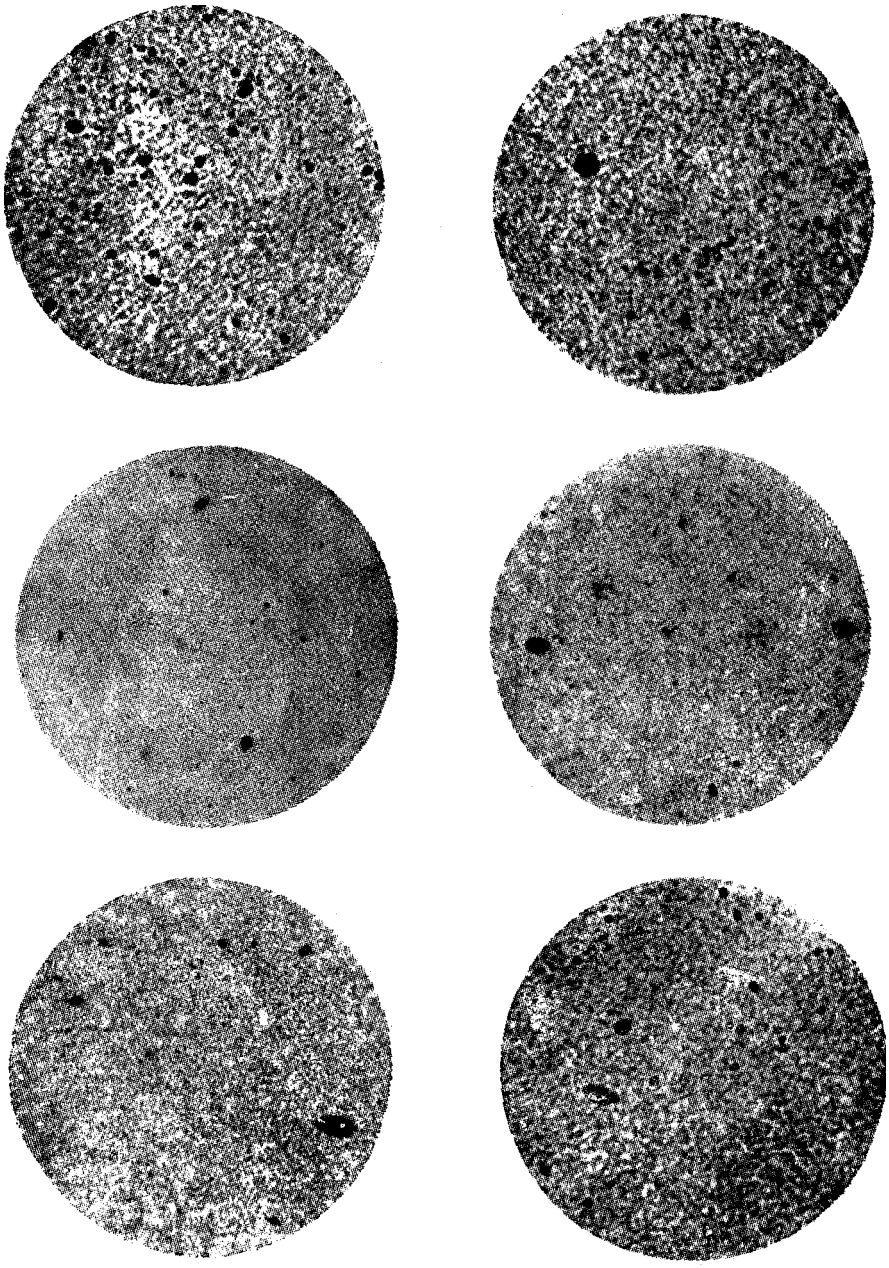


FIG. 3–8 SATISFACTORY CARBON BLACK DISPERSION

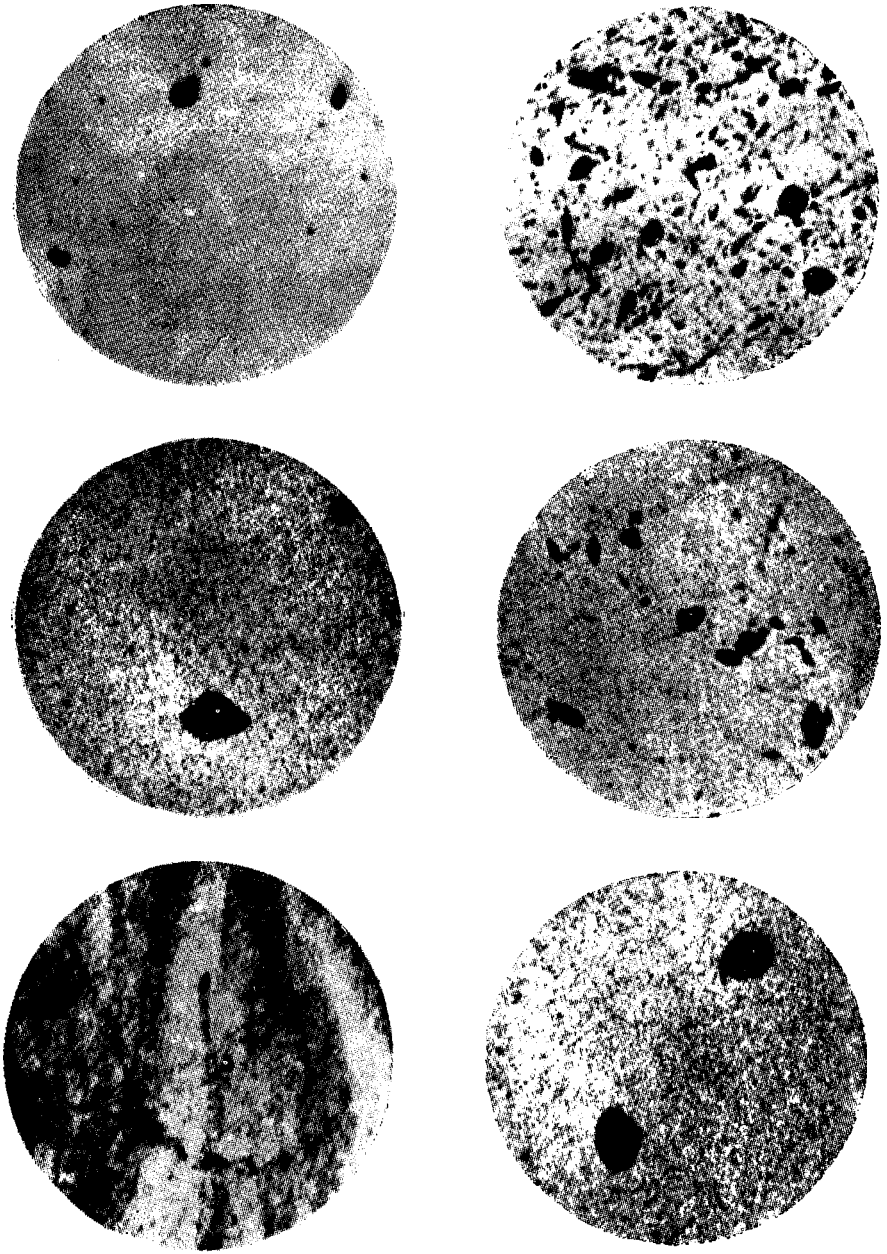


FIG. 9-14 UNSATISFACTORY CARBON BLACK DISPERSION

D-2. PROCEDURE

D-2.1 The test sheet is placed on a PE terephthalate film of 0·15 mm thickness and heated at 140 ± 1°C for 48 ± 2 hours.

At the end of this period, the sheet is repressed to remove any distortion which may have occurred during the ageing period.

APPENDIX E

(Clause B-7-1)

AGEING TEST FOR INSULATION AND SHEATH

E-0. GENERAL

E-0.1 This test method applies to PE with a density up to and including 0 940 g/cm^3 and for wall thicknesses $\geqslant$ 0·8 mm. For the time being, it does not apply to PE with a density greater than 0·940 g/cm^3 and for wall thicknesses $<$ 0·8 mm.

E-l. TESTING APPARATUS

E-l.l The testing apparatus consists of:

a) punching device for dumb-bell test pieces as in Fig. 1 and 2,

b) cutting device for obtaining smooth plane-parallel surfaces of the pieces,

c) electrically heated cabinet with natural air flow,

d) tensile strength testing machine, and

e) clamping device with two grips corresponding to the requirements of the pieces.

E-2. AGEING PROCEDURE

E-2.1 The test pieces prepared according to **B-3** shall be suspended vertically in the middle of the air oven according to **E-l** for 10 X 24 hours at 100 ± 2°C. The distance between the test pieces shall be at least 20 mm. Immediately after ageing, the test pieces are taken out of the air oven and left at ambient temperature for at least 16 hours, avoiding direct sunlight.

E-3. EXPRESSION OF RESULTS

E-3.1 The median of the values of elongation at break shall be recorded as the elongation at break. It shall be not less than 300 percent, unless the relevant specification requires another value.

INTERNATIONAL SYSTEM OF UNITS (SI UNITS)

Base Units

QUANTITY	UNIT	SYMBOL
Length	metre	m
Mass	kilogram	kg
Time	second	s
Electric current	ampere	K
Thermodynamic temperature	kelvin	
Luminous intensity	candela	cd
Amount of substance	mole	mol

Supplementary Units

QUANTITY	UNIT	SYMBOL
Plane angle	radian	rad
Solid angle	steradian	sr

Derived Units

QUANTITY	UNIT	SYMBOL	DEFINITION
Force	newton	N	1 N - 1 kg.m/s^2
Energy	joule	J	I J = 1 N.m
Power	watt	W	1 W = 1 J/s
Flux	weber	Wb	1 Wb = 1 V.s
Flux density	tesla	T	1 T = 1 Wb/m^2
Frequency	hertz	Hz	1 Hz = 1 c/s (s^{-1})
Electric conductance	siemen	S	1 S = 1 A/V
Electromotive force	volt	V	1 V = 1 W/A
Pressure, stress	pascal	Pa	1 Pa = 1 N/m^2

INDIAN STANDARDS INSTITUTION

Manak Bhavan, 9 Bahadur Shah Zafar Marg, NEW DELHI 110002

Telephones : 26 60 21, 27 01 31 **Telegrams : Manaksanstha**

Regional Offices':		Telephone
Western : Novelty.Chambers, Grant Road	BOMBAY 400007	89 65 28
Eastern : 5 Chowringhee Approach	CALCUTTA 700072	27 50 90
Southern : C. I. T. Campus, Adyar	MADRAS 600113	41 24 42
Northern : B69, Phase VII	S.A.S. NAGAR (MOHALI) 160051	8 78 26
Branch Offices:		
'Pushpak', Nurmohamed Shaikh Marg, Khanpur	AHMADABAD 380001	2 03 91
'F' Block, Unity Bldg, Narasimharaja Square	BANGALORE 560002	22 48 05
Gangotri Complex, Bhadbhada Road, T.T. Nagar	BHOPAL 462003	6 27 16
22E Kalpana Area	BHUBANESHWAR 751014	5 36 27
5-8-56C, L. N. Gupta Marg	HYDERABAD 500001	22 10 83
R 14 Yudhister Marg, C Scheme	JAIPUR 302005	6 98 32
117/418 B Sarvodaya Nagar	KANPUR 208005	4 72 92
Patliputra Industrial Estate	PATNA 800013	6 28 08
Hantex Bldg (2nd Floor), Rly Station Road	TRIVANDRUM 695001	32 27

Printed at Printograph, New Delhi , India